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TITLE: (6) On the theory of stellar shockwaves

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TEXT: Stellar shockwaves are usually investigated using the "classical" theory of shockwaves in a moving gas (L.D.Landau and Ye.M.Lifshits, Mekhanika sploshnykh sred (Mechanics of Continuous Media), GITTL, Moscow, 1953). This theory predicts that the temperature behind a shockwave moving with a velocity of the order of 1000 km/sec in a stellar envelope should be of the order of 2×10^7 deg, whereas observations indicate that the maximum temperature on the surface of a new star immediately after the explosion is of the order of $10^4 - 10^5$ deg. One suggestion to obviate this difficulty has been that the temperature is reduced as a result of the emission of radiation into the surrounding space. The present paper is concerned with another mechanism responsible for the reduction in the temperature. Thus, a stellar envelope consists of a gas-radiation mixture and the latter may often play an appreciable role. When a shockwave

Card 1/4 4

passes through such a medium a part of the wave energy may be spent not only in increasing the internal energy of the gas but also in increasing the radiation density. Hence, for given shockwave velocity, the temperature behind the wave front may be less than the temperature given by the "classical" theory. The present paper is concerned with the generalization of the "classical" theory and considers the thermodynamic equilibrium of a gas-radiation mixture. It is shown that the equation for the adiabatic curve for such a system is 4

$$\frac{7(\gamma_2 - 1) + \beta_2(8 - 6\gamma_2)}{\gamma_2 - 1} \cdot \frac{\beta_1}{\beta_2} \cdot \frac{T_2}{T_1} - \frac{7(\gamma_1 - 1) + \beta_1(8 - 6\gamma_1)}{\gamma_1 - 1} -$$

$$- \frac{1 - \beta_1}{1 - \beta_2}\left(\frac{T_2}{T_1}\right)^4 + \frac{\beta_1}{\beta_2}\,\frac{1 - \beta_2}{1 - \beta_1}\left(\frac{T_1}{T_2}\right)^3 = \frac{2q\beta_1}{RT_1} - \frac{2F\beta_1}{R_1T_1\rho_1u_1} \qquad (9)$$

where subscripts 1 and 2 represent the state of the gas before

Card 2/4

and after the passage of the shockwave, γ is the adiabatic exponent for the gas, β is the ratio of the gas pressure to the total pressure, T is the temperature of the mixture, q is the amount of bound energy liberated in the wave front, F is the flux of radiation from the surface of the shockwave front and u is the velocity of the gas relative to the wave front. This result is then used to find the discontinuities in physical parameters across the shockwave front. The results obtained are very similar to those considered by K. P. Stanyukovich (Neustanovivshiyesya dvizheniya sploshnoy sredy ["Non-steady Motion of a Continuous Medium"], Gostekhizdat, 1955). It is shown that the ratio of the gas to total pressure behind the shock front decreases sharply with increasing temperature discontinuity at the wave front. When the amount of wave energy spent in increasing the radiation density is taken into account, it is found that the density discontinuity is increased and the temperature discontinuity is appreciably reduced. In particular, for a shockwave moving with a velocity of the order of 1000 km/sec in a solar-type stellar envelope, the temperature behind the

wave front is lower by a factor of 18.5 as compared to the temperature calculated from the "classical" shockwave theory. The general conclusion is that effects associated with the increase in the radiation density must not in general be ignored. There are 1 figure and 1 table.

ASSOCIATION: L'vovskaya astronomicheskaya observatoriya (L'vov Astronomical Observatory)

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